AIRPORT CAPACITY ENHANCEMENT

TACTICAL INITIATIVE

ORLANDO INTERNATIONAL AIRPORT

NORTH CROSSFIELD TAXIWAY SYSTEM

Orlando International Airport, looking south, showing the site of the north crossfield taxiway system.

Orlando International Airport

Airport Capacity Enhancement Tactical Initiative

North Crossfield Taxiway System

November 1995

Prepared jointly by the U.S. Department of Transportation, Federal Aviation Administration, and the Greater Orlando Aviation Authority.

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EXECUTIVE SUMMARY

The Federal Aviation Administration's (FAA) Office of System Capacity and Requirements (ASC) has undertaken a series of initiatives to identify, evaluate, and implement capacity improvements which are achievable in the near term and will provide more immediate relief for chronic delay-problem airports. Airport Capacity Enhancement (ACE) Action Teams have been established at selected airports to assess near-term, tactical initiatives and guide them through implementation.

Orlando International Airport has been a national leader in aviation activity growth for over a decade. Passenger traffic growth during the decade has averaged 10% annually, consistently exceeding the national average. Current forecasts show that the airport will exceed 30 million annual passengers by the year 2000, and over 50 million passengers by the year 2015.

This study was initiated by the Greater Orlando Aviation Authority (GOAA) and the FAA to evaluate the capacity benefits of a north crossfield taxiway system and to help determine the optimum time to initiate this airfield improvement. In order to evaluate these issues, the delay savings (improved taxi times) which would result from the north crossfield taxiway system were determined. All of the taxiway and terminal improvements studied are designed to facilitate the delivery of departures to the runways and arrivals to the gates. Since most of the delay encountered at the airport is due to the capacity (or lack thereof) of the runway configuration in use, any taxiway improvement must be considered in light of the potential savings offered by one runway configuration over the other. Furthermore, some improvements, such as a midfield taxiway extension, may provide less of a benefit than indicated if the improvement only serves to permit the departures to reach the departure queue faster, but depart at the same time as they would have without the improvement in place.

The results of this study indicate that both the proposed midfield taxiway extension and the single north crossfield taxiway provide significant savings in taxi time. The location of a fourth airside terminal in the southwest quadrant of the airport provides an initial benefit for the present airport and fourth runway configuration. However, if the single north crossfield taxiway is added, any proposed location of the fourth airside terminal produces essentially the same total taxi times for the airport. Additional savings can be achieved by locating a fourth airside terminal in the northeast quadrant of the airport, operating a single north crossfield taxiway with opposing traffic, adding a stub bypass, and providing a dual crossfield taxiway. These results apply to the present airport configuration as well as the configuration with the fourth runway.

Additional results indicate that the closure of one midfield taxiway should be accomplished as soon as possible before traffic demand increases further to minimize taxi costs. However, regardless of when the closure occurs, the addition of a single north crossfield taxiway would reduce taxi costs significantly.

The reader should note that this study considers only the taxi time savings of proposed improvements. There are other improvement benefits, such as greater flexibility for air traffic controllers to cross traffic on the ground rather than in the air, which cannot be assessed by the methods used in this study. Therefore, decisions on when and where to construct the various improvements examined should not be based entirely on the results of this study. Rather, the information contained in this report should provide useful information as one component of the decision making process.

Section 1

Introduction

Objective

This study was initiated by the Greater Orlando Aviation Authority (GOAA) and the Federal Aviation Administration (FAA) to evaluate the capacity benefits of a north crossfield taxiway system and to help determine the optimum time to initiate this airfield improvement. In order to evaluate these issues, the delay savings (improved taxi times) which would result from the north crossfield taxiway system were determined. For the purposes of this study, the delay savings benefits were calculated for different demand levels forecast for the airport and for different stages of airport development. The study was later expanded to include impacts on taxi times associated with different locations for the fourth airside terminal.

Background

Since 1985, the FAA has sponsored Airport Capacity Design Team Studies at airports across the country affected by delay. Representatives from airport operators, air carriers, other airport users, and aviation industry groups have worked together with FAA representatives to identify and analyze capacity problems at each individual airport and recommend improvements which have the potential for reducing delays. The improvements recommended by the Capacity Design Teams have emphasized construction of new runways and taxiways, installation of enhanced navigation facilities and equipment, and changes in air traffic control procedures. Typically, these improvements are implemented through established, long-term planning processes.

The FAA's Office of System Capacity and Requirements (ASC) has recently undertaken a series of initiatives to identify, evaluate, and implement capacity improvements which are achievable in the near term and will provide more immediate relief for chronic delay-problem airports. Airport Capacity Enhancement (ACE) Action Teams will be established at selected airports, again made up of representatives from airport operators, air carriers, other airport users, FAA, and aviation industry groups, to assess these near-term, tactical initiatives and guide them through implementation.

An Airport Capacity Design Team Study at Orlando International Airport was completed in 1990 with the publication of an Airport Capacity Enhancement Plan in October of that year. The plan recommended, for immediate action, the construction of a north crossfield taxiway. The construction of an additional parallel north crossfield taxiway was considered, however, the 1990 report concluded that additional study was required prior to making a recommendation for construction.

Orlando International Airport (MCO) has been a national leader in aviation activity growth for over a decade. Passenger traffic growth during this time has averaged 10% annually, consistently exceeding the national average. Current forecasts show that the airport will exceed 30 million annual passengers by the year 2000, and over 50 million annual passengers by the year 2015.

It is desirable to route both arrivals and departures so that they take a minimum amount of taxi time at the airport. This frequently necessitates crossing aircraft from one side of the airspace complex to the other while they are in the air. As the traffic increases and/or weather becomes a factor, more of this crossing of traffic must be done on the ground. With the current taxiway configuration, and the eventual construction of a fourth runway, this will result in a significant increase in the distance each aircraft must taxi. There will be a corresponding increase in aircraft operating costs and the potential for delays. Taxi distances can exceed 14,000 feet when taxi for direction of flight is necessary. Naturally, as the traffic increases, there will be a more frequent requirement for the greater taxi distances, with a resultant increase in costs to the users.

Additional operating costs and delays will occur in the future due to a bottleneck at the mid-crossfield taxiways. These delays will be significantly compounded when one of the mid-crossfield taxiways is closed for planned construction/reconstruction.

The need to cross aircraft from one side of the airfield to the other on the ground, and the desire to avoid significant delays in the near future, make the construction of a north crossfield taxiway a high priority.

Prior to the start of the current Master Plan update, the FAA requested that GOAA consider the construction of a dual north crossfield taxiway instead of the presently planned single version. This action would increase the utility of the taxiway system by permitting two-way taxiing on the north crossfield taxiway system.

While GOAA's long range plan includes an additional north crossfield taxiway and the extension of Runway 17R to eliminate the arrival restrictions caused by the proximity of the taxiway to its approach path, the current Master Plan update is evaluating other airport improvements that could affect the timing and need for the single and/or dual north crossfield taxiway. Furthermore, planning, and environmental approvals for a single north crossfield taxiway are complete. If the additional taxiway was added now, it would require the preparation of a new planning study and environmental assessment. This would delay the start of design for the single taxiway system. The dual taxiway will also require the extension of Runway 17R and the removal of several buildings. These will be very expensive and GOAA is not prepared to undertake this work now. However, GOAA agreed that a study of the taxi time savings benefits of a single, and of a dual, north crossfield taxiway was needed to help determine the proper time to implement these projects. They also felt the study would help them with other decisions being made in their current Master Plan Update.

Scope

The ACE Action Team limited its analysis to aircraft activity on the airport's taxiway system and the determination of aircraft taxi times. They did not consider runway delays or delays due to taxiway congestion. They considered the technical and operational feasibility of the proposed airfield improvements, but did not address environmental and design issues or the cost of development and construction. These issues need to be addressed in future airport planning studies. The data generated in this study may be used in these follow-on studies.

Methodology

The ACE Action Team, consisting of representatives from the FAA and the Greater Orlando Aviation Authority, and various aviation industry groups (see Appendix A), met periodically for review and coordination. The Team considered various airfield configuration options.

The basis for this report was the Orlando International Airport Capacity Design Team Study completed in 1990. It provided not only the necessary data base for the calculations of taxi times, but also served as a reference for comparing new results with other recommended improvements to the airport contained in the original study.

Several key factors from the 1990 study were included in this study. Among them were the direct operating costs associated with each class of aircraft and the method of calculating annual delay. In addition, airport configuration data analyzed in the previous study, including traffic flow and the distribution of aircraft on the runways, were used.

Analysis consisted of calculating the taxi times with and without the additional north crossfield taxiway and other planned airport improvements. A computer model was constructed to accomplish this for various daily demand levels and airport configurations, including those with the new runway (17L/35R). Daily demand levels used for the baseline, Future 1 and Future 2 activity levels were kept consistent with the 1990 study as follows:

- Baseline — 294,000 annual operations,
- Future 1 — 400,000 annual operations,
- Future 2 — 600,000 annual operations.

The difference in taxi times between the various configurations represented the daily aircraft operating time savings provided by each improvement. That data was then annualized and converted into dollar savings for the year. The weighted-average aircraft direct operating costs at Orlando International Airport were assumed to be $1,658 per hour.

Figure 1. Orlando International Airport — Existing Configuration

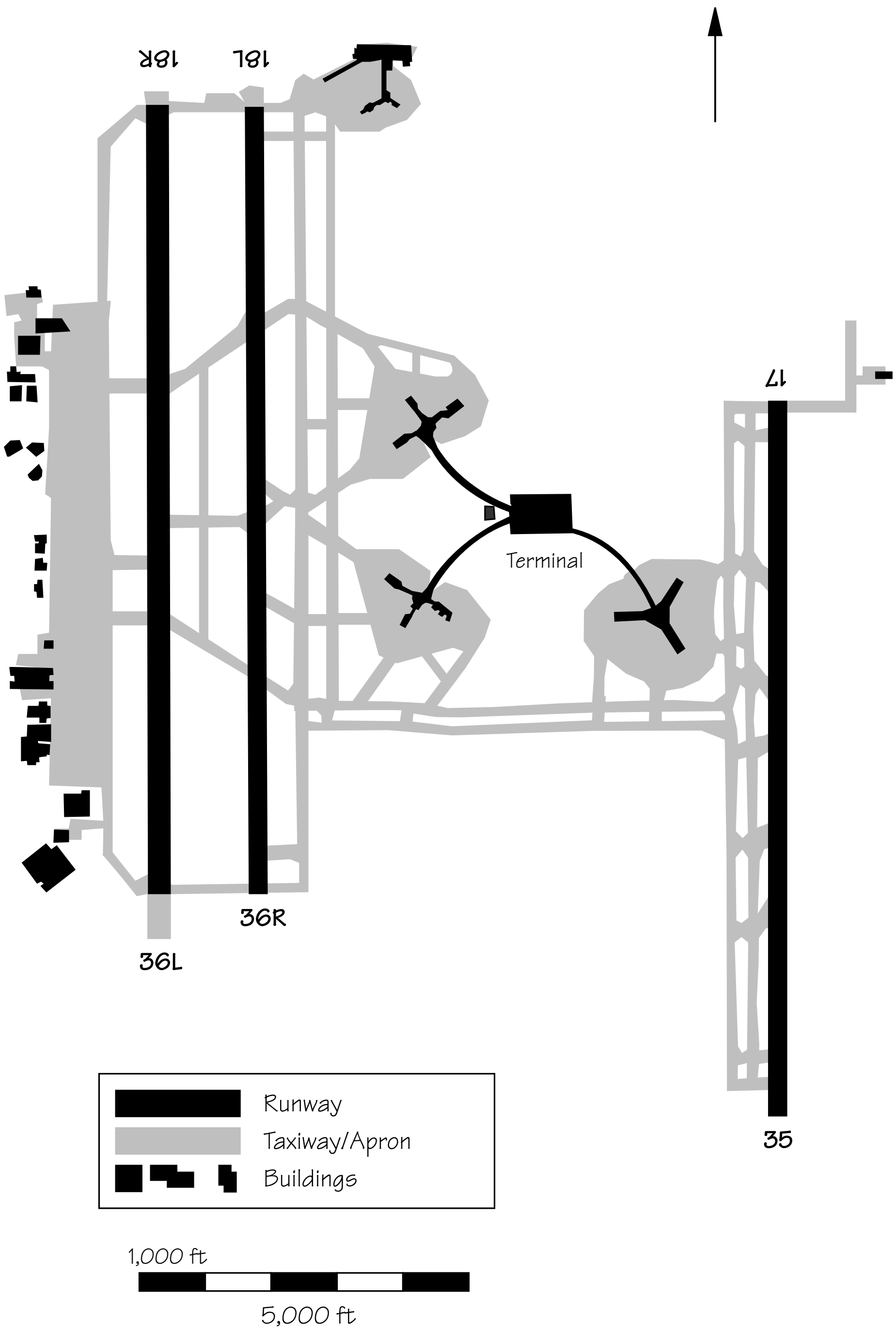
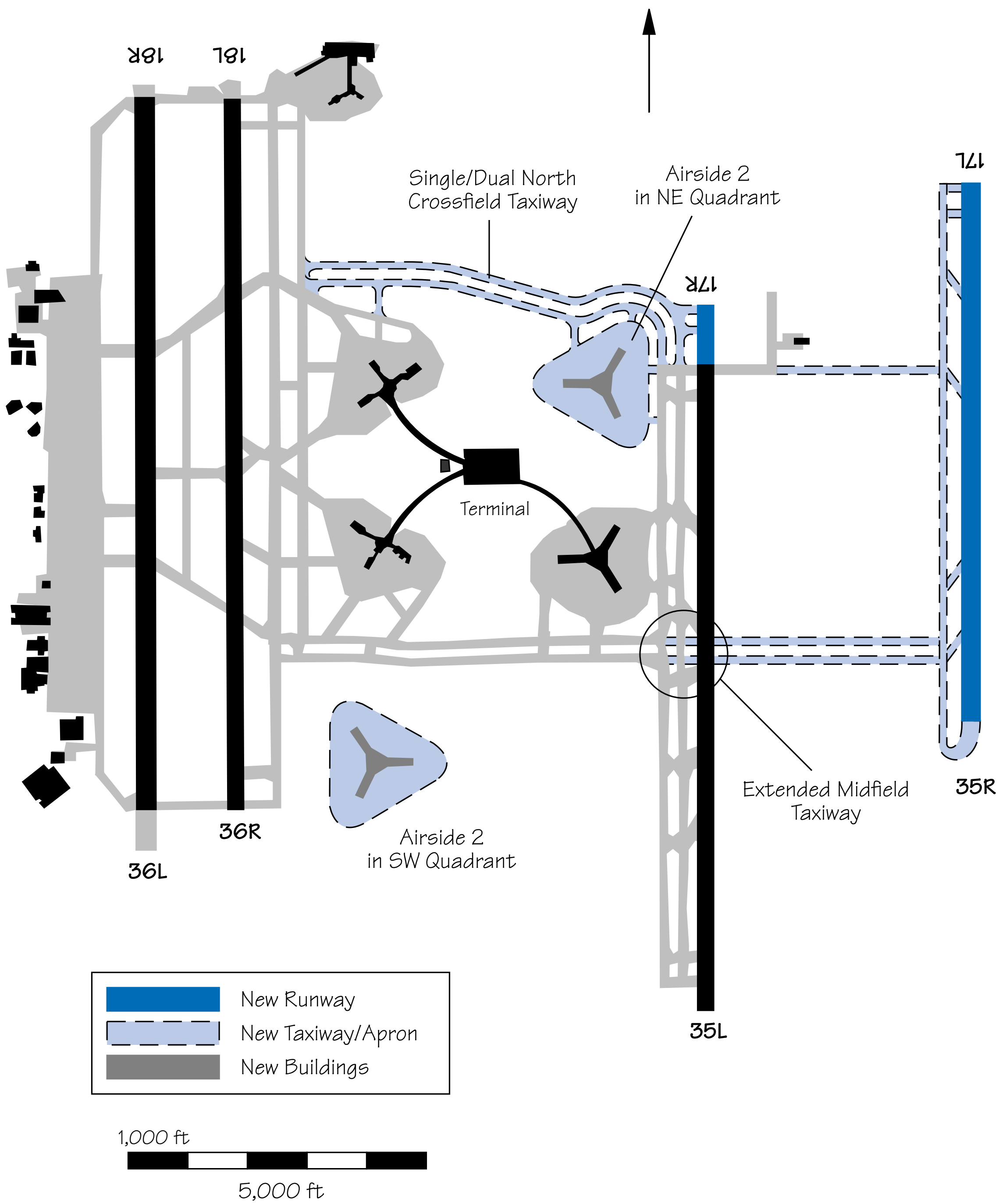


Figure 2. Orlando International Airport — Future Configuration



SECTION 2

NORTH CROSSFIELD TAXIWAY SYSTEM ALTERNATIVES

Figure 1 shows the current layout of the airport. Figure 2 shows the various improvements analyzed in this study. In studying the capacity benefits of the north crossfield taxiway, the Airport Capacity Enhancement (ACE) Action Team evaluated the various airfield configurations listed on the following page.

The assumptions made in the design of the alternatives include:

a. The fourth runway (Rwy 17L/35R) will be used during high demand levels for overflow departures and excessive arrivals. The runway will also be utilized for arrivals during heavy departure demand on 17R/35L and 18L/36R.

b. Airport configurations with dual north crossfield taxiway assumed the extension of runway 17R to minimize TERPS restrictions.

c. The present south flow configuration has arrivals on 18R and 17R with departures on 18L and 17R. (This is a change for this study from the configuration in the original study which had arrivals predominately on 18L and 17R with departures on 18R and 17R.)

For alternatives 1 - 12, total taxi time for arrivals and departures were based on an approximate 50/50 distribution of aircraft taxiing from either a) east or west side of airport to the opposite side, or b) remaining on one side of the airport complex.

Alternatives 13 - 15 were based on the analysis of delay times encountered by opposing traffic at the entry point of the midfield taxiway.

Alternatives 16A - 18B involved the use of the north crossfield taxiway with one midfield taxiway closed, eliminating any delay due to opposing traffic.

Alternative 19 was performed to examine a proposed stub-bypass at the end of the north crossfield taxiway.

Alternatives 20 - 24 included the fourth runway (17L/35R) in the present airport configuration with single and dual north crossfield taxiways added. All assume extended midfield taxiway.

Alternatives

No.	Description of Taxiway Configuration
1.	Present Airport Configuration
2.	Present Airport Configuration with Airside 2 in NE Quadrant
3.	Present Airport Configuration with Airside 2 in SW Quadrant
4.	Present Airport Configuration with Extended Midfield Taxiway
5.	Present Airport Configuration with Extended Midfield Taxiway and Airside 2 in NE Quadrant
6.	Present Airport Configuration with Extended Midfield Taxiway and Airside 2 in SW Quadrant
7.	Present Airport Configuration with Extended Midfield Taxiway and Single North Crossfield Taxiway
8.	Present Airport Configuration with Extended Midfield Taxiway and Dual North Crossfield Taxiway
9.	Present Airport Configuration with Extended Midfield Taxiway and Airside 2 in NE Quadrant and Single North Crossfield Taxiway
10.	Present Airport Configuration with Extended Midfield Taxiway and Airside 2 in SW Quadrant and Single North Crossfield Taxiway
11.	Present Airport Configuration with Extended Midfield Taxiway and Airside 2 in NE Quadrant and Dual North Crossfield Taxiway
12.	Present Airport Configuration with Extended Midfield Taxiway and Airside 2 in SW Quadrant and Dual North Crossfield Taxiway
13.	Present Airport Configuration with Extended Midfield Taxiway and Closure of One Midfield Taxiway
14.	Present Airport Configuration with Extended Midfield Taxiway and Closure of One Midfield Taxiway with Airside 2 in NE Quadrant
15.	Present Airport Configuration with Extended Midfield Taxiway and Closure of One Midfield Taxiway with Airside 2 in SW Quadrant
16A.	Present Airport Configuration with Extended Midfield Taxiway and Closure of One Midfield Taxiway and Single North Crossfield Taxiway (Counter-clockwise Flow)
16B.	Present Airport Configuration with Extended Midfield Taxiway and Closure of One Midfield Taxiway and Single North Crossfield Taxiway (Clockwise Flow)
17A.	Present Airport Configuration with Extended Midfield Taxiway and Closure of One Midfield Taxiway with Airside 2 in NE Quadrant and Single North Crossfield Taxiway (Counter-clockwise Flow)
17B.	Present Airport Configuration with Extended Midfield Taxiway and Closure of One Midfield Taxiway with Airside 2 in NE Quadrant and Single North Crossfield Taxiway (Clockwise Flow)
18A.	Present Airport Configuration with Extended Midfield Taxiway and Closure of One Midfield Taxiway with Airside 2 in SW Quadrant and Single North Crossfield Taxiway (Counter-clockwise Flow)
18B.	Present Airport Configuration with Extended Midfield Taxiway and Closure of One Midfield Taxiway with Airside 2 in SW Quadrant and Single North Crossfield Taxiway (Clockwise Flow)
19A.	Present Airport Configuration with Extended Midfield Taxiway and two-way traffic on Single North Crossfield Taxiway and Stub By-pass at end of Taxiway and Airside 2 in NE Quadrant
19B.	Present Airport Configuration with Extended Midfield Taxiway and two-way traffic on Single North Crossfield Taxiway and Airside 2 in NE Quadrant.
20.	Present Airport Configuration with Extended Midfield Taxiway and with Fourth Runway
20A.	Present Airport Configuration with extended Midfield taxiway and with Fourth Runway and Airside 2 in the NE Quadrant
20B.	Present Airport Configuration with Extended Midfield Taxiway and with Fourth Runway and Airside 2 in the SW Quadrant
21.	Present Airport Configuration with Extended Midfield Taxiway and with Fourth Runway and Airside 2 in NE Quadrant and Single North Crossfield Taxiway
22.	Present Airport Configuration with extended Midfield taxiway and with Fourth Runway and Airside 2 in SW Quadrant and Single North Crossfield Taxiway
23.	Present Airport Configuration with Extended Midfield Taxiway and with Fourth Runway and Airside 2 in NE Quadrant and Dual North Crossfield Taxiway
24.	Present Airport Configuration with Extended Midfield Taxiway and with Fourth Runway and Airside 2 in SW Quadrant and Dual North Crossfield Taxiway

SECTION 3

RESULTS

The results of the experiments (modeling of the alternatives) can be summarized based on their yearly cost comparison with one another. The annual cost savings of each alternative (the difference in annual cost of an alternative compared with that of the present airport configuration) is intended to demonstrate its relative merit and the order of preferential treatment for implementation.

Figure 3 provides a summary of the annual taxi cost savings for the various alternatives in millions of dollars. Note that the taxi cost savings for each of the individual alternatives represents that alternative's taxing costs less the Do Nothing (present airport configuration) alternative's taxiing costs (see Figure 4).

The experiments were designed to show the effects of extending the midfield taxiway, constructing a single and a dual north crossfield taxiway, and placement of a fourth airside terminal in either the northeast (NE) or southwest (SW) quadrant of the airport. The alternatives were treated as stand alone improvements or combined with each other as requested by the team.

While Figures 3 and 4 summarize the results of the experiments, the individual experiment results are shown in greater detail in Figures 5, 6, and 7. The cost savings represent the additional benefit of an improvement over the improvements to the left of it unless noted otherwise. Figure 5 shows the savings after adding the fourth airside terminal, additional savings once the midfield extension is added, and on top of that, savings after adding the single and dual north crossfield taxiways. Figure 6 shows the savings after adding a fourth runway, then adding a fourth airside terminal, then a single north crossfield taxiway, and finally, a dual north crossfield taxiway. Figure 7 lists the costs when one midfield taxiway is closed, plus the savings when a single north crossfield taxiway is added. Note that each figure shows savings for the fourth airside terminal located in either the northeast (NE), or the southwest (SW) quadrant of the airport.

As can be seen in Figures 3 through 7, the experiment results indicate that at the Future 1 demand level:

- The placement of the fourth airside terminal in the SW quadrant of the present airport configuration will save about $1.13 million in taxi cost. If this terminal is located in the NE quadrant, it will add some $440 thousand in taxi cost.

- The midfield taxiway extension provides a significant reduction in taxi costs compared with the present airport configuration at all demand levels and any fourth airside terminal location. The savings are $1.70 million over the present airport configuration.
- A single north crossfield taxiway will save $2.45 million in taxi costs for the present airport configuration with midfield taxiways extended. The construction of a dual north crossfield taxiway will not save any taxi time over the single north crossfield taxiway for the present airport configuration with a midfield extension.
- After the single north crossfield taxiway is constructed, there will be an advantage to operating it in both directions (opposing traffic) if the fourth airside terminal is located in the NE quadrant. This procedure, although generating some delay, can save about $0.85 million for Future 1 demand and $1.30 million for the Future 2 demand level.

  If a stub by-pass is in place, the figures are $0.99 million for Future 1 and $1.52 million for Future 2. However, the advantage of this procedure will be lessened by the experience of encountering delays and controller workload during times of peak operations. As the demand increases during the day, more delays will be experienced by the aircraft operating during this time.

  If a dual north crossfield taxiway is put in place of the stub by-pass, the savings would rise to $1.28 million for Future 1 and $1.97 million for the Future 2 demand level with the fourth airside terminal in the NE quadrant.
- The addition of the fourth airside terminal in the SW quadrant with the single north crossfield taxiway and the midfield taxiway extension in place will save about $4.07 million in taxi cost. If the terminal is located in the NE quadrant, the savings will be $3.74 million in taxi cost.
- The introduction of a fourth parallel runway (Runway 17L/35R) will increase the cost of taxi by $5.60 million over the cost of the present airport configuration with the midfield taxiways extended.
- With the fourth parallel runway and midfield taxiway extension in place, the addition of the north crossfield taxiway and placement of the fourth airside terminal in the NE will save $2.63 million in taxi cost. The addition of the dual north crossfield taxiway will save $1.15 million more in this case.
- With the fourth parallel runway and midfield extension in place, the addition of the north crossfield taxiway and placement of the fourth airside in the SW will save $2.69 million in taxi cost. The addition of the dual north crossfield taxiway will not save any additional taxi time in this case.
- The closure of one midfield taxiway will cost about $4.23 million in the present airport configuration with midfield extension because of delays encountered by opposing traffic. With the fourth airside terminal in the NE quadrant, the cost would be $4.98 million. If the fourth airside terminal is in the SW quadrant, the cost of the closure is about $4.66 million.
- With the addition of a single north crossfield taxiway with traffic heading westbound on it and eastbound on the midfield taxiway (counter-clockwise traffic), the cost of closure of the midfield taxiway for the present airport configuration with midfield extension would be $4.87 million. If the fourth airside terminal is added in the NE, the cost would be about $2.48 million. With the fourth airside in the SW, the cost should be about $7.55 million.
- With the addition of a single north crossfield taxiway with traffic heading eastbound on it and westbound on the midfield taxiway (clock wise traffic), the cost of closure of one midfield taxiway for the present airport configuration with midfield taxiway extension will be reduced to $2.30 million. If the fourth airside terminal is added in the NE, the cost would be reduced to $2.78 million. With the fourth airside in the SW, the cost would be reduced to $3.76 million.

Figure 3 Summary of Annual Taxi Cost Savings

Alternative		Estimated Annual Taxi Cost Savings Future 1	Future 2
2.	Present Airport with Airside 2 in NE	($442,999)	($847,919)
3.	Present Airport with Airside 2 in SW	$1,125,438	$1,124,122
4.	Present Airport with Midfield Extension	$1,704,727	$2,461,721
5.	Present Airport with Airside 2 in NE/Midfield Extension	$1,328,255	$1,764,537
6.	Present Airport with Airside 2 in SW/Midfield Extension	$2,800,769	$3,635,351
7.	Present Airport with Single North Crossfield Taxiway	$4,151,065	$6,238,364
8.	Present Airport with Dual North Crossfield Taxiway	$4,151,065	$6,238,364
9.	Taxiway Closed, 2 in NE and Single North Crossfield Taxiway	$3,735,169	$5,447,699
10.	Airside 2 in SW and Single North Crossfield Taxiway	$4,057,457	$5,641,651
11.	Airside 2 in NE and Dual North Crossfield Taxiway	$5,018,744	$7,415,766
12.	Airside 2 in SW and Dual North Crossfield Taxiway	$4,057,457	$5,641,651
13.	Closure of one Midfield Taxiway	$2,521,838)	($6,806,444)
14.	Closure of one Midfield Taxiway and Airside 2 in NE	($3,648,762)	*
15.	Closure of one Midfield Taxiway and Airside 2 in SW	($1,860,366)	*
16A.	1 Midfield Taxiway Closed, 1 North Crossfield-Westbound	($3,166,264)	($4,865,683)
16B.	1 Midfield Taxiway Closed, 1 North Crossfield-Eastbound	($587,885)	($1,084,834)
17A.	1 Midfield Taxiway Closed, 1 North Crossfield-W, Airside 2 in NE	($1,146,487)	($1,848,572)
17B.	1 Midfield Taxiway Closed, 1 North Crossfield-E, Airside 2 in NE	($1,449,841)	($1,978,950)
18A.	1 Midfield Taxiway Closed, 1 North Crossfield-W, Airside 2 in SW	($4,751,807)	($7,733,391)
18B.	1 Midfield Taxiway Closed, 1 North Crossfield-E, Airside 2 in SW	($955,748)	($1,582,750)
19A.	Stub By-Pass, 1 North Crossfield with opposing Traffic, Airside 2 in NE	$4,723,204	$6,970,446
19B.	1 North Crossfield with Opposing Traffic, Airside 2 in NE	$4,588,152	$6,746,831
20.	Four Runways - 3 Airsides	($3,892,495)	($5,901,059)
20A.	Four Runways - Airside 2 in NE	($3,695,920)	($5,695,487)
20B.	Four Runways - Airside 2 in SW	($2,339,260)	($4,065,059)
21.	Four Runways - Airside 2 in NE, Single North Crossfield	($1,261,493)	($2,048,162)
22.	Four Runways - Airside 2 in SW, Single North Crossfield	($1,202,383)	($2,238,831)
23.	Four Runways - Airside 2 in NE, Dual North Crossfield	($108,910)	($260,485)
24.	Four Runways - Airside 2 in SW, Dual North Crossfield	($1,202,383)	($2,238,831)

Notes:

* Opposing traffic impractical at the Future 2 demand level.

1. Alternatives 4-24 include midfield taxiway extension.
2. Numbers in parenthesis ( ) are costs.

Figure 4 Summary of Annual Taxi Cost

Alternative		Estimated Annual Taxi Cost Future 1	Future 2
1.	Present Airport - 3 Airsides	$70,503,914	$105,554,826
2.	Present Airport with Airside 2 in NE	$70,946,913	$106,402,745
3.	Present Airport with Airside 2 in SW	$69,378,476	$104,430,704
4.	Present Airport with Midfield Extension	$68,799,187	$103,093,105
5.	Present Airport with Airside 2 in NE/Midfield Extension	$69,175,659	$103,790,289
6.	Present Airport with Airside 2 in SW/Midfield Extension	$67,703,145	$101,919,475
7.	Present Airport with Single North Crossfield Taxiway	$66,352,849	$99,316,462
8.	Present Airport with Dual North Crossfield Taxiway	$66,352,849	$99,316,462
9.	Airside 2 in NE and Single North Crossfield Taxiway	$66,768,745	$100,107,127
10.	Airside 2 in SW and Single North Crossfield Taxiway	$66,446,457	$99,913,175
11.	Airside 2 in NE and Dual North Crossfield Taxiway	$65,485,171	$98,139,060
12.	Airside 2 in SW and Dual North Crossfield Taxiway	$66,446,457	$99,913,175
13.	Closure of One Midfield Taxiway	$73,025,752	$112,361,269
14.	Closure of one Midfield Taxiway and Airside 2 in NE	$74,152,676	*
15.	Closure of one Midfield Taxiway and Airside 2 in SW	$72,364,280	*
16A.	1 Midfield TWY Closed, 1 North Crossfield-Westbound	$73,670,178	$110,420,509
16B.	1 Midfield TWY Closed, 1 North Crossfield-Eastbound	$71,091,799	$106,639,660
17A.	1 Midfield TWY Closed, 1 North Crossfield-W, Airside 2 in NE	$71,650,401	$107,403,398
17B.	1 Midfield TWY Closed, 1 North Crossfield-E, Airside 2 in NE	$71,953,755	$107,533,776
18A.	1 Midfield TWY Closed, 1 North Crossfield-W, Airside 2 in SW	$75,255,721	$113,288,217
18B.	1 Midfield TWY Closed, 1 North Crossfield-E, Airside 2 in SW	$71,459,662	$107,137,576
19A.	Stub By-Pass, 1 North Crossfield with opposing Traffic, Airside 2 in NE	$65,780,710	$98,584,380
19B.	1 North Crossfield with Opposing Traffic, Airside 2 in NE	$65,915,762	$98,807,995
20.	Four Runways- 3 Airsides	$74,396,410	$111,455,884
20A.	Four Runways- Airside 2 in NE	$74,199,835	$111,250,313
20B.	Four Runways- Airside 2 in SW	$72,843,174	$109,619,885
21.	Four Runways, Airside 2 in NE, Single North Crossfield	$71,765,407	$107,602,988
22.	Four Runways, Airside 2 in SW, Single North Crossfield	$71,706,297	$107,793,657
23.	Four Runways, Airside 2 in NE, Dual North Crossfield	$70,612,824	$105,815,311
24.	Four Runways, Airside 2 in SW, Dual North Crossfield	$71,706,297	$107,793,657

Notes:

* Opposing traffic impractical at the Future 2 demand level.

Alternatives 4-24 include midfield taxiway extension.

Figure 5. Present Airport Taxi Costs and Improvement Cost Savings (millions of dollars)

	Present Airport *Taxi Costs*	Fourth Terminal (A/S 2) *Savings (Costs)*	Midfield Extension *Savings*	Single North Crossfield *Savings*	Single North Crossfield w/Opposing Traffic *Savings*	Single North Crossfield w/Opposing Traffic & Stub By-Pass *Savings*	Dual North Crossfield (added to Single North Crossfield) *Savings*
	Alt 1	**None**	**Alt 4**	**Alt 7**	**None**	**None**	**Alt 8**
Future 1	70.50	—	1.70	2.45	—	—	0.00
Future 2	105.55	—	2.46	3.78	—	—	0.00
	Alt 1	**Alt 2-NE**	**Alt 5-NE**	**Alt 9-NE**	**Alt 19B-NE**	**Alt 19A-NE**	**Alt 11-NE**
Future 1	70.50	(0.44)	1.77	2.41	0.85	0.14	1.28
Future 2	105.55	(0.85)	2.61	3.68	1.30	0.22	1.97
	Alt 1	**Alt 3-SW**	**Alt 6-SW**	**Alt 10-SW**	**None**	**None**	**Alt 12-SW**
Future 1	70.50	1.13	1.68	1.26	—	—	0.00
Future 2	105.55	1.12	2.51	2.01	—	—	0.00

Notes:
1. Savings are additive left to right, except for dual north crossfield taxiway.
2. Savings listed for each improvement is the additional savings over the savings of the adjacent improvement to the left, except for dual north crossfield taxiway which is additive to the single north crossfield.

Figure 6. Present Airport Taxi Costs and Improvement Cost Savings (millions of dollars)

	Present Airport with Midfield Extension *Costs*	Fourth Runway *Savings (Costs)*	Fourth Terminal (A/S 2) *Savings*	Single North Crossfield *Savings*	Dual North Crossfield *Savings*
	Alt 4	**Alt 20**	**Alt 20A-NE**	**Alt 21-NE**	**Alt 32-NE**
Future 1	68.80	(5.60)	0.20	2.43	1.15
Future 2	103.09	(8.36)	0.21	3.65	1.79
	Alt 4	**Alt 20**	**Alt 20B-SW**	**Alt 22-SW**	**Alt 24-SW**
Future 1	68.80	(5.60)	1.55	1.14	0.00
Future 2	103.09	(8.36)	1.84	1.83	0.00

Notes:
1. Savings are additive left to right.
2. Savings listed for each improvement are the additional savings over the savings of the adjacent improvement to the left, except for dual north crossfield taxiway which is additive to the single north crossfield.

Figure 7. Midfield Taxiway Closure Costs and Improvement Cost Savings (millions of dollars)

	Present Airport with Midfield Extension and Fourth Terminal *Costs*	Closure of One Midfield Taxiway *Savings (Costs)*	Single North Crossfield with Westbound Traffic (Midfield Eastbound) with Closure of One Midfield *Savings (Costs)*	Single North Crossfield with Eastbound Traffic (Midfield Westbound) with Closure of One Midfield *Savings*
	Alt 4*	**Alt 13**	**Alt 16A**	**Alt 16B**
Future 1	68.80	(4.23)	(0.64)	1.93
Future 2	103.09	(9.27)	1.94	5.72
	Alt 5-NE	**Alt 14-NE**	**Alt 17A-NE**	**Alt 17B-NE**
Future 1	69.18	(4.98)	2.50	2.20
Future 2	103.79	n/a	n/a	n/a
	Alt 6-SW	**Alt 15-SW**	**Alt 18A-SW**	**Alt 18B-SW**
Future 1	67.70	(4.66)	(2.89)	0.90
Future 2	101.92	n/a	n/a	n/a

Notes:

* Alternative 4 does not include a fourth airside terminal (A/S 2).

1. Savings are additive left to right, except for single north crossfield taxiway with eastbound traffic.
2. Savings listed for each improvement are the additional savings over the savings of the adjacent improvement to the left, except for dual north crossfield taxiway which is additive to the single north crossfield.
3. The costs for closure of one midfield taxiway are annual costs. The actual cost may be greater or less depending on the length of closure.

Section 4

Findings

All of the taxiway and terminal improvements are designed to facilitate the delivery of departures to the runways and arrivals to the gates. Since most of the delay encountered at the airport is due to the capacity (or lack of capacity) of the runway configuration in use, any taxiway improvement must be considered in light of the potential savings offered by one runway configuration over the other. For example, the introduction of a fourth runway at Orlando slightly increases the taxi time, but substantially decreases the arrival and departure delays. This fact can account for a decision to forego the increased taxi time and decide to build and operate a fourth runway to accommodate the increase in traffic demand.

Furthermore, some improvements, such as the midfield taxiway extension, may provide less of a benefit than indicated in this study if the improvement only serves to permit the departures to reach the departure queue faster, but depart at the same time as they would have without the improvement in place. On the other hand, early delivery of a single departure to the runway at the start of the queue has the effect of saving delay to all subsequent departures. Arrivals usually benefit from improved taxiways by reduced taxi times to their gates.

Keeping these thoughts in mind, based on the results of the experiments, the following statements can be made concerning each improvement and terminal location with and without a fourth runway:

- The midfield taxiway extension provides a significant cost savings for any fourth airside location and the present airport configuration for all demand levels.
- A single north crossfield taxiway provides significant cost savings at all demand levels for any fourth airside terminal location with the present airport configuration and when a fourth runway is added to the airport. However, it provides the greatest benefit if the fourth airside terminal is constructed in the NE quadrant.
- The SW location of the fourth airside terminal is more favorable than the NE for the present airport and fourth runway configuration. However, when the single north crossfield taxiway is added, there is no significant difference in taxi cost with either location of the fourth airside terminal.
- Additional savings can be achieved with the fourth airside terminal located in the NE quadrant if the single north crossfield taxiway is operated with opposing traffic. Adding a stub bypass increases the savings slightly more for each demand level.
- A dual north crossfield taxiway provides a slightly increased savings over a single crossfield taxiway with a stub bypass when the fourth airside terminal is located in the NE quadrant. The dual crossfield taxiway improvements with the fourth airside terminal in the NE reduces the cost of the taxi time by about $1.28 million over the single crossfield taxiway at the Future 1 demand level.
- The addition of the fourth runway increases taxi cost. (This will be more than offset by reduced runway delay costs.) Adding the single north crossfield taxiway reduces the cost to about the same level for both locations of the fourth airside terminal. The dual north crossfield taxiway provides additional savings if the fourth airside terminal is located in the NE quadrant.
- The cost of the closure of one midfield taxiway can be significantly reduced by constructing a single north crossfield taxiway to relieve the opposing traffic situation. Furthermore, if the fourth airside terminal is added prior to closure of a midfield taxiway, the single north crossfield taxiway will significantly reduce the cost of closure, particularly if the fourth airside is located in the northeast quadrant.

In summary, the results indicate that both the midfield taxiway extension and the single north crossfield taxiway provide significant savings in taxi time. The location of the fourth airside terminal in the SW provides an initial benefit for the present airport and fourth runway configuration. However, if the single north crossfield taxiway is added, any proposed location of the fourth airside terminal produces essentially the same total taxi times for the airport.

Additional savings can be achieved for the NE terminal location by operating the single north crossfield taxiway with opposing traffic, adding a stub bypass, and finally, providing a dual crossfield taxiway.

The above observations apply to the present airport configuration as well as the configuration with the fourth runway.

Finally, the closure of one midfield taxiway should be accomplished as soon as possible before traffic demand increases further to minimize taxi costs. However, regardless of when the closure occurs, the addition of the single north crossfield taxiway would significantly reduce taxi costs.

The reader should note that the above discussion only considers the taxi time savings of the improvements. There are other benefits of the improvements that could not be assessed by the methods used for this study, such as greater flexibility for air traffic controllers to cross traffic on the ground rather than in the air. Therefore, decisions on when and where to construct the various improvements examined here should not be based entirely on the results of this study. However, this report should provide useful information as one component of the decision making process.

APPENDIX A

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APPENDIX B

DATA INPUTS AND ASSUMPTIONS

Figure 8. Demand Forecasts

Aircraft Operations

Year	Air Carier	Air Taxi/ Commuter	Genreal Aviation	Military	Total
1990	208,340	29,000	40,700	4,800	282,840
1995	283,200	34,300	53,700	4,800	376,000
2000	329,760	39,700	67,900	4,800	442,160
2005	384,000	45,000	80,000	4,800	513,800

Figure 8 depicts the demand forecasts for MCO taken from the Orlando International Airport Master Plan Report, May 1988, page 3.6.

While the data presented in Figure 8 was used for modeling purposes, it should be noted that the Orlando International Airport Master Plan was updated during the course of this study. The revised aircraft operations projections are as follows: 1995 — 360,300;
2000 — 447,100;
2005 — 535,700.

Following are the demand levels used for this study which were taken from the 1990 Airport Capacity Enhancement Plan for Orlando International Airport.

Baseline	294,000
Future 1	400,000
Future 2	600,000

Figure 9. Summary of Direct Operating Costs by Aircraft Class

Class	Percentage	Cost/Hour ($)	Weighted Cost
1	09.6	3,275	313.24
2	67.7	1,908	1,291.86
3	15.9	323	51.18
4	06.8	20	1.37

Average cost per hour = $1,657.65

APPENDIX C

COMPUTER MODEL AND METHODOLOGY

In order to analyze the delay savings (improved taxi times) of the various alternatives in this study, a computer program was developed. Following is a brief description of the computer program and the methodology used.

The Computer Model

Travel times for each alternative were computed using a program written by the Technical Center. This program used the same input data to RDSIM and ADSIM that was used in the 1990 Design Team study. Input data consisted of traffic schedules for north and south flow configurations for each demand level, an airport link diagram representing the taxiway and runway structure of the airport, and a list of taxiway paths that aircraft utilize traveling to and from the runways and gates. Output is a list of travel times for each airside complex to/from each runway. Travel times for each airside complex is the product of the time to travel on a taxiway path and the number of aircraft that use that path. This data is inserted into a spreadsheet where it is summarized and annual travel time costs are computed.

The travel time program was executed with different input data to produce the list of alternatives in Figure 3. For example, to produce results for an alternative having the fourth airside in the northeast quadrant, the program used a different traffic schedule with aircraft using the gates at the fourth airside and a different list of taxiway paths allowing aircraft to taxi to/from the fourth airside terminal. This produced different results because the new taxiway paths have different travel times.

Methodology

The experiments were conducted by calculating the average taxi times for arrivals from each runway to each gate area and for departures from each gate area to each runway for both the north and south traffic flow.

The distribution of departures from each gate area to each runway was used to calculate the total taxi time for departures. Likewise, the distribution of arrivals from each runway to each gate area was used to calculate the total taxi time for arrivals. The calculations were repeated for each airfield configuration and for each demand level (294,000, 400,000, and 600,000 annual operations).

The total taxi times for the various alternatives were annualized and compared to determine the taxi time savings of one alternative versus another.

APPENDIX D

ABBREVIATIONS

ACE	Airport Capacity Enhancement
ADSIM	Airfield Delay Simulation Model
APM	Airport Machine — computer simulation model
ARTS	Automated Radar Terminal System
ASC	Office of System Capacity and Requirements
ATC	Air Traffic Control
ATCT	Airport Traffic Control Tower
CAT	Category — of instrument landing system
FAA	Federal Aviation Administration
GOAA	Greater Orlando Aviation Authority
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
MCO	Orlando International Airport
MI	Miles
NE	North East
NM	Nautical Miles
RDSIM	Runway Delay Simulation Model
RWY	Runway
SW	South West
TERPS	Terminal Instrument Procedures
TRACON	Terminal Radar Approach Control
TWY	Taxiway
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

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